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(54) **TIRE INFLATION SYSTEM WITH PRESSURIZED GAS ROUTING THROUGH A SPINDLE**

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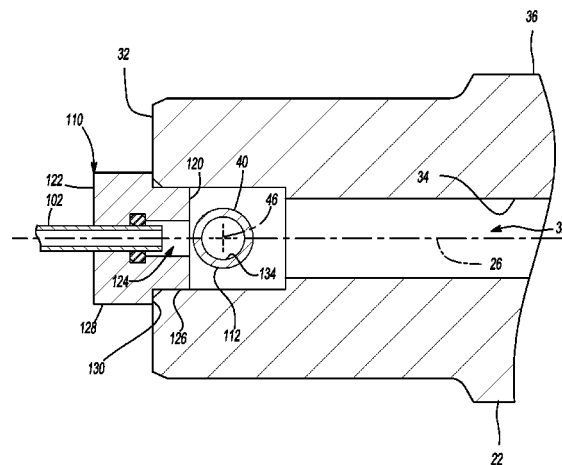
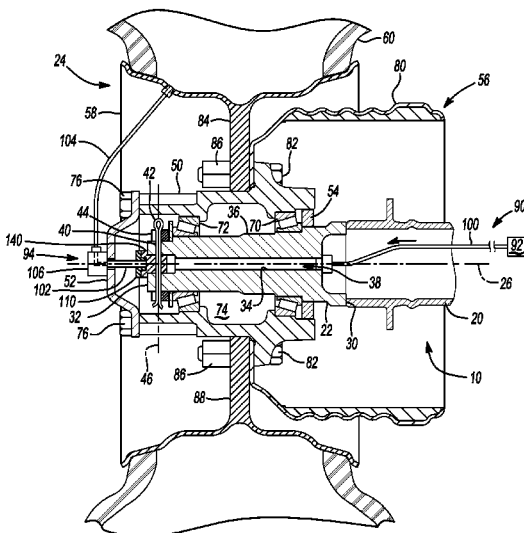
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(57) **ABSTRACT**

A tire inflation system having a spindle that has a spindle fastener hole and spindle passage through which a pressurized gas flows for inflating a tire. An adapter or a fastener tube may inhibit pressurized gas from flowing from the spindle passage into the spindle fastener hole.

**16 Claims, 4 Drawing Sheets**



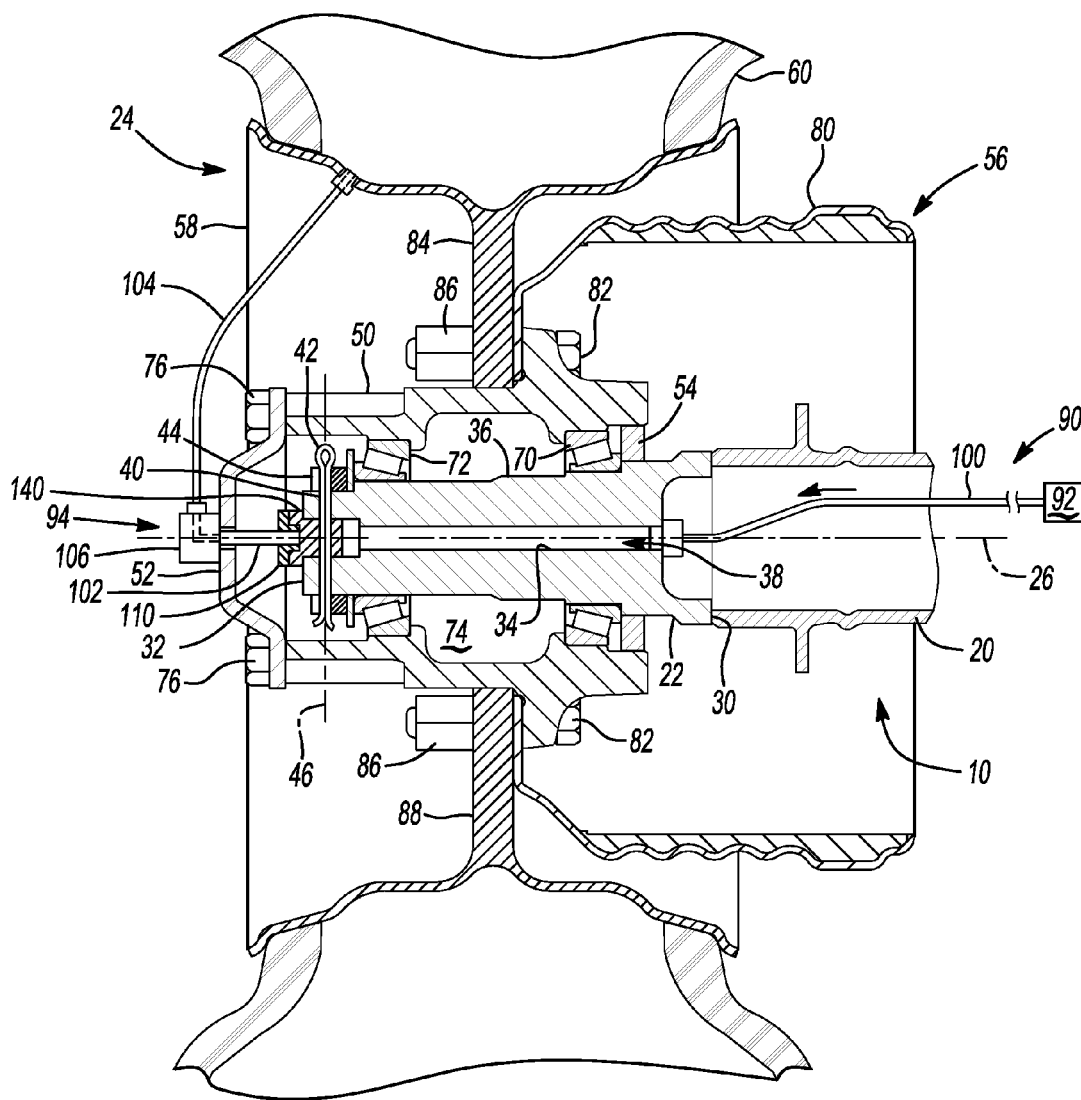
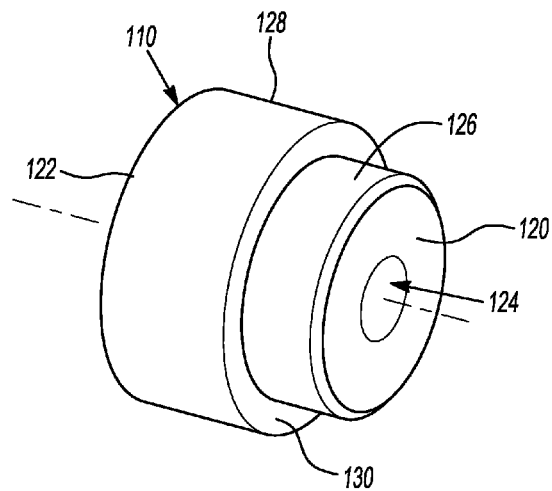
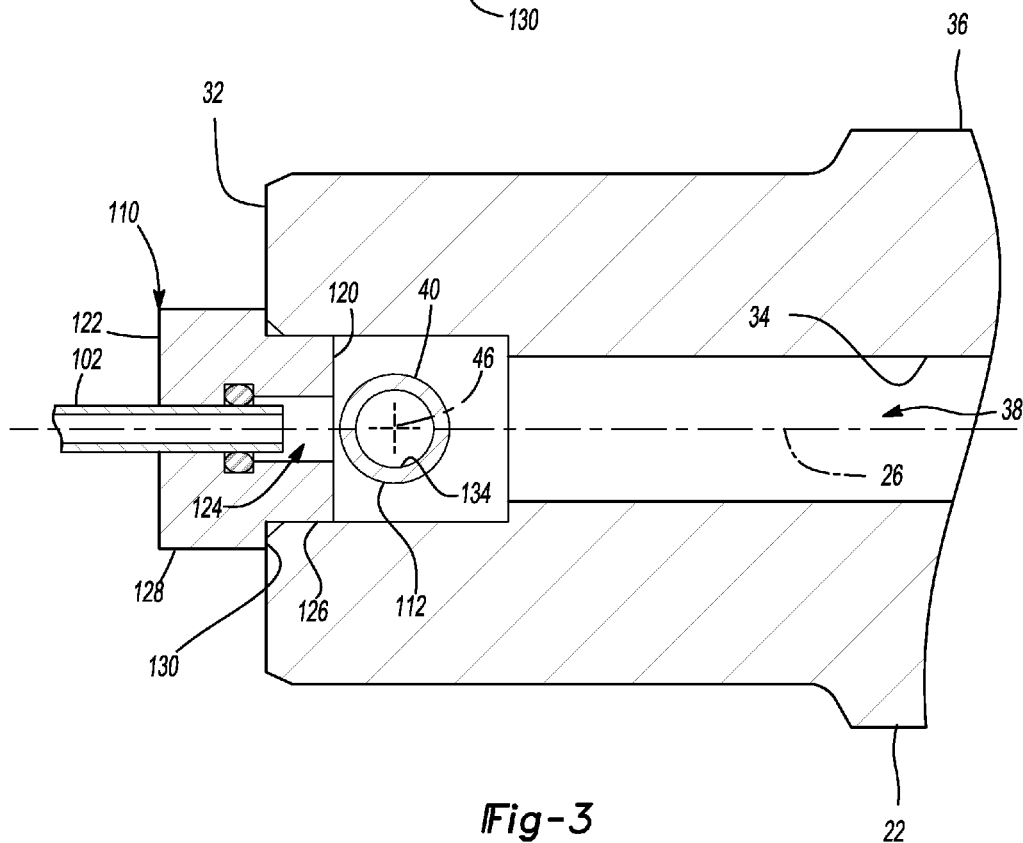


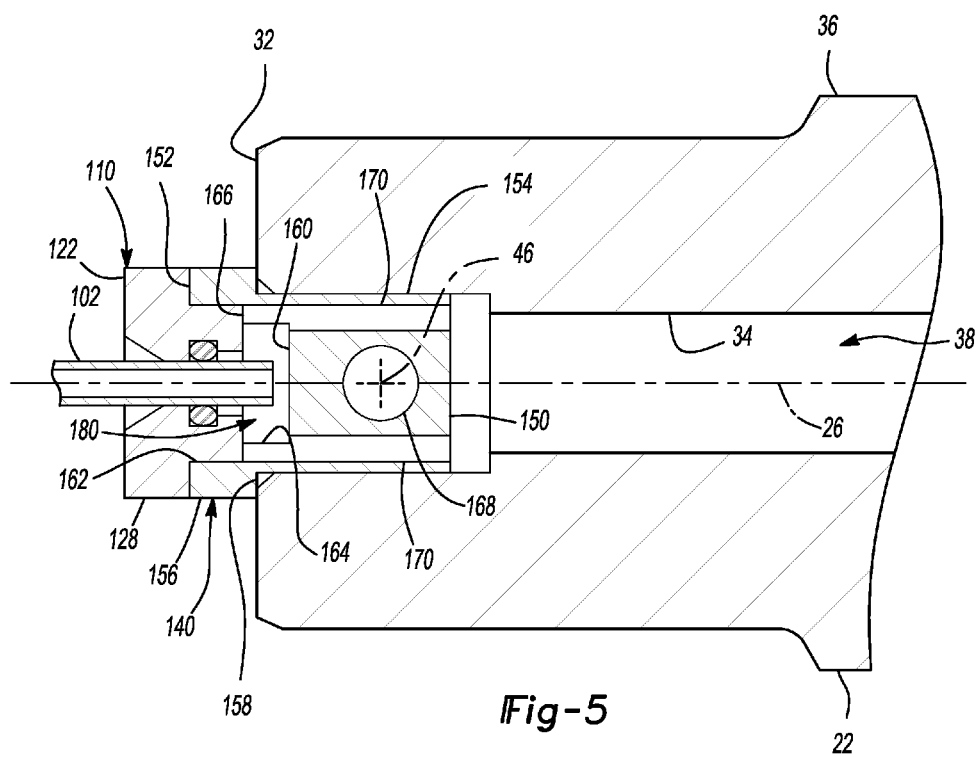
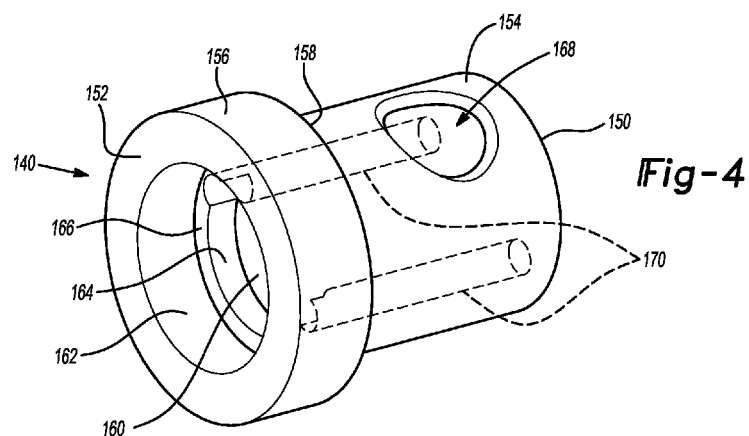
Fig-1

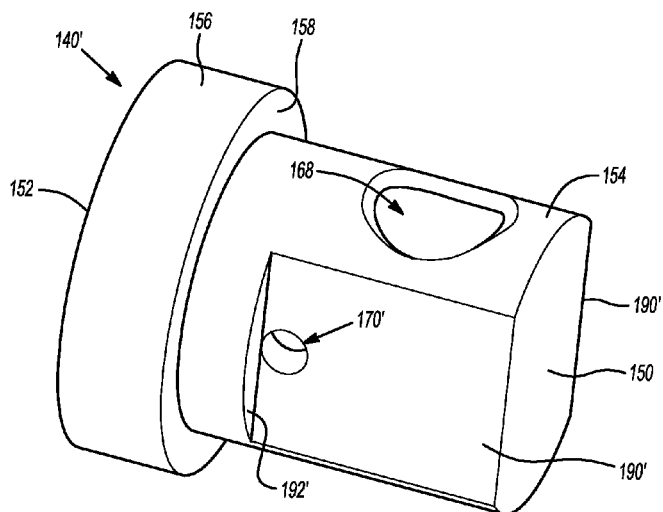


*Fig-2*

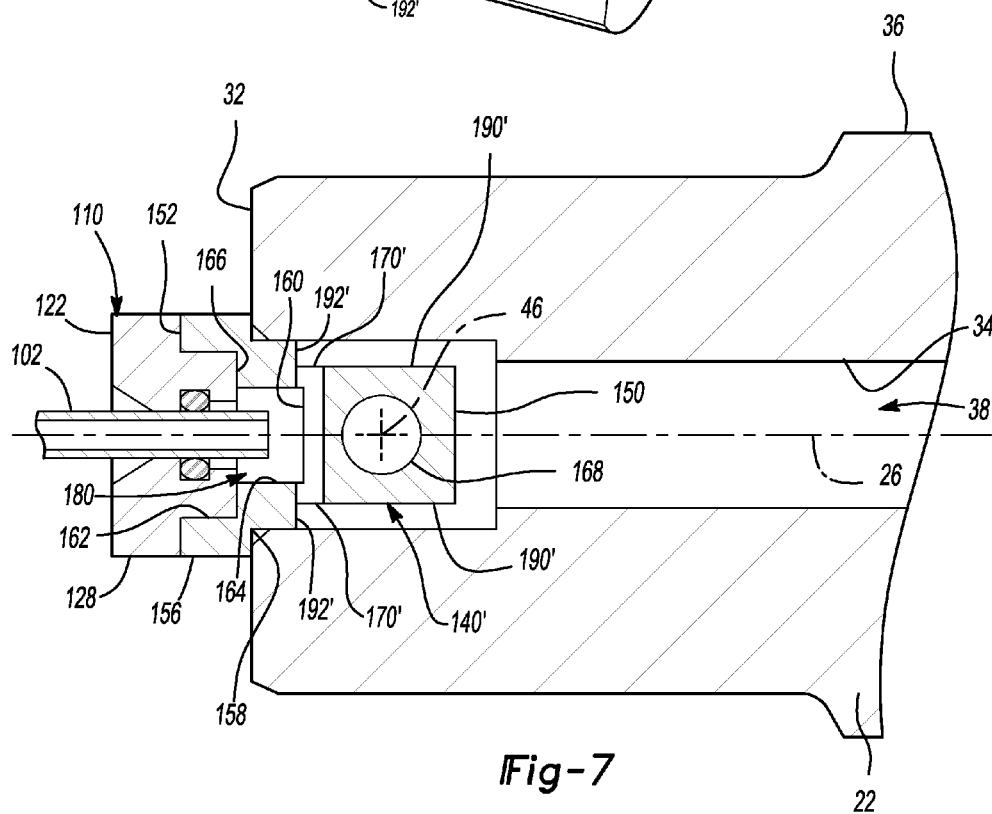


*Fig-3*





**Fig-6**



**Fig-7**

1

# TIRE INFLATION SYSTEM WITH PRESSURIZED GAS ROUTING THROUGH A SPINDLE

## TECHNICAL FIELD

This patent application relates to a tire inflation system in which pressurized gas is routed through a spindle.

## BACKGROUND

A tire inflation system is disclosed in U.S. Pat. No. 7,931,061.

## SUMMARY

In at least one embodiment, a tire inflation system is provided. The tire inflation system may include a spindle, an adapter, a fitting, and a fastener. The spindle may rotatably support a wheel and may include a spindle passage and a spindle fastener hole. Pressurized gas may flow through the spindle passage. The spindle fastener hole may extend through the spindle and may intersect the spindle passage. The adapter may be disposed in the spindle passage. The adapter may include an adapter fastener hole and an adapter passage. The adapter fastener hole may be aligned with the spindle fastener hole. The adapter passage may receive the pressurized gas from the spindle passage. The adapter passage may not be fluidly connected to the adapter fastener hole. The fitting may be disposed proximate the adapter. The fitting may receive the pressurized gas from the adapter passage and may be fluidly connected to the tire. The fastener may extend through the spindle fastener hole and the adapter fastener hole.

In at least one embodiment, a tire inflation system is provided. The tire inflation system may include a spindle, a fitting, a fastener tube, and a fastener. The spindle may rotatably support a wheel and may include a spindle passage and a spindle fastener hole. The spindle passage may be disposed along an axis. Pressurized gas for inflating a tire may flow through the spindle passage. The spindle fastener hole may extend through the spindle and may intersect the spindle passage. The fitting may be disposed in the spindle passage. The fitting may receive pressurized gas from the spindle passage and may be fluidly connected to the tire. The fastener tube may extend through the spindle fastener hole. The fastener tube may inhibit pressurized gas from flowing from the spindle passage into the spindle fastener hole. The fastener may extend through the fastener tube to inhibit movement of the spindle nut that is disposed on the spindle.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section view of an exemplary wheel end assembly and a tire inflation system.

FIG. 2 is a fitting that may be provided with a wheel end assembly.

FIG. 3 is a top section view of a portion of the wheel end assembly with the adapter of FIG. 2.

FIG. 4 is a perspective view of a first embodiment of an adapter that may be provided with the tire inflation system.

FIG. 5 is a top section view of a portion of the wheel end assembly with the adapter of FIG. 4.

FIG. 6 is a perspective view of a second embodiment of an adapter that may be provided with the tire inflation system.

2

FIG. 7 is a top section view of a portion of the wheel end assembly with the adapter of FIG. 6.

## DETAILED DESCRIPTION

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale; some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

Referring to FIG. 1, a portion of an exemplary axle assembly 10 is shown. The axle assembly 10 may be provided with a motor vehicle like a truck, bus, farm equipment, military transport or weaponry vehicle, or cargo loading equipment for land, air, or marine vessels, or a trailer that may be provided with a motor vehicle.

The axle assembly 10 may be configured as a non-drive axle in one or more embodiments. As such, the axle assembly 10 may not receive torque from a power source, such as an internal combustion engine or electric motor, that may be used to propel the vehicle. The axle assembly 10 may or may not be steerable. In a non-drive axle configuration, the axle assembly 10 may include an axle housing 20, a spindle 22, and a wheel end assembly 24.

The axle housing 20 may receive or support various components of the axle assembly 10. In addition, the axle housing 20 may facilitate mounting of the axle assembly 10 to the vehicle.

The spindle 22 may be provided with or may be fixedly positioned with respect to the axle assembly 10. In a steerable configuration, the spindle 22 may be provided with or may be fixedly positioned with respect to a steering knuckle rather than the axle housing 20. The spindle 22 may generally extend along but may not rotate about an axis 26. In at least one embodiment, the spindle 22 may include a first spindle end surface 30, a second spindle end surface 32, an internal surface 34, an external surface 36, a spindle passage 38, and a spindle fastener hole 40.

The first spindle end surface 30 may be disposed proximate or may engage the axle housing 20. Alternatively, the first spindle end surface 30 may be omitted in a configuration in which the spindle 22 is integrally formed with the axle housing 20 or is not provided as a separate component. The second spindle end surface 32 may be disposed opposite the first spindle end surface 30.

The internal surface 34 may extend between the first spindle end surface 30 and the second spindle end surface 32 and may at least partially define the spindle passage 38. Pressurized gas for inflating a tire may flow through the spindle passage 38. For example, the spindle passage 38 may define a conduit that receives pressurized gas or the spindle passage 38 may receive a conduit, such as a hose, tubing or the like that may receive pressurized gas and that may extend at least partially through the spindle passage 38.

The external surface 36 may be disposed opposite the internal surface 34. The external surface 36 of the spindle 22 may support one or more wheel bearings that may rotatably support the wheel end assembly 24 as will be discussed in more detail below.

The spindle fastener hole 40 may be configured to receive a fastener 42, such as a cotter pin, that may help secure or

inhibit movement of a spindle nut **44** that may be disposed on the spindle **22**. The spindle nut **44** may help inhibit axial movement of the wheel end assembly **24**. The spindle fastener hole **40** may extend along a spindle fastener hole axis **46**. The spindle fastener hole axis **46** may intersect and may be disposed substantially perpendicular to the axis **26** in one or more embodiments. The spindle fastener hole **40** may intersect the spindle passage **38** and may extend completely through the spindle **22** such that the spindle passage **38** may separate or bisect the spindle fastener hole **40**.

The wheel end assembly **24** may be rotatably disposed on the spindle **22**. The wheel end assembly **24** may include a hub **50**, a hub cap **52**, wheel end seal assembly **54**, a brake subsystem **56**, a wheel **58**, and a tire **60**.

The hub **50** may be rotatably disposed on the spindle **22** and may be configured to rotate about the axis **26**. For instance, one or more wheel bearings may be mounted on spindle **22** and may rotatably support the hub **50**. In FIG. 1, a first wheel bearing **70** and a second wheel bearing **72** are provided in a cavity **74** that is located between the spindle **22** and the hub **50**. The first wheel bearing **70** may be disposed inboard or further from the second spindle end surface **32** than the second wheel bearing **72**.

The hub cap **52** may be coupled to the hub **50** with one or more fasteners **76**. As such, the hub cap **52** may rotate with the hub **50**.

The wheel end seal assembly **54** may be disposed between the spindle **22** and the hub **50**. The wheel end seal assembly **54** may inhibit contaminants from entering the cavity **74** and may help retain lubricant in the cavity **74**. In at least one embodiment, the wheel end seal assembly **54** may be fixedly disposed with respect to the hub **50** and may rotate about the axis **26** and with respect to the spindle **22**.

The brake subsystem **56** may be adapted to slow or inhibit rotation of at least one associated wheel **58**. For example, the brake subsystem **56** may be configured as a friction brake, such as a drum brake or a disc brake. In FIG. 1, a portion of the brake subsystem **56** is shown with a drum brake configuration. In a drum brake configuration, a brake drum **80** may be fixedly disposed on the hub **50** with one or more fasteners **82**, such as wheel lug studs. The brake drum **80** may extend continuously around brake shoe assemblies (not shown) that may be configured to engage the brake drum **80** to slow rotation of an associated wheel **58**.

The wheel **58** may be fixedly disposed on the hub **50**. For example, the wheel **58** may be mounted on the hub **50** via the fasteners **82**. More specifically, the wheel **58** may have a wheel mounting flange **84** that may have a set of holes that may each receive a fastener **82**. A lug nut **86** may be threaded onto each fastener to secure the wheel **58** to the fasteners **82** and the hub **50**. The lug nut **86** may engage or may be disposed proximate an outboard side **88** of the wheel mounting flange **84** that may face away from the brake drum **80** or toward the hub cap **52**. The wheel **58** may be configured to support the tire **60**. The tire **60** may be a pneumatic tire that may be inflated with a pressurized gas or pressurized gas mixture.

A tire inflation system **90** may be associated with the wheel end assembly **24**. The tire inflation system **90** may be disposed on the vehicle and may be configured to provide a pressurized gas or pressurized gas mixture to one or more tires **60**. For clarity, the term "pressurized gas" may refer to either a pressurized gas or a pressurized gas mixture. The tire inflation system **90** may include a control system that may monitor and control the inflation of one or more tires **60**, a pressurized gas source **92**, and a gas supply subsystem **94**.

The pressurized gas source **92** may be configured to supply or store a volume of a pressurized gas or pressurized gas mixture, like air or nitrogen. For example, the pressurized gas source **92** may be a tank and/or a pump like a compressor. The pressurized gas source **92** may be disposed on the vehicle and may provide a pressurized gas or pressurized gas mixture at a pressure that is greater than or equal to a desired inflation pressure of a tire **60**. As such, the pressurized gas source **92** may inflate a tire or maintain a desired tire pressure.

The gas supply subsystem **94** may fluidly connect the pressurized gas source **92** to the tire **60**. The gas supply subsystem **94** may include one or more conduits, such as a hose, tubing, pipe, or combinations thereof. In FIG. 1, a first conduit **100**, a connection conduit **102**, and a second conduit **104** are shown. The first conduit **100** may receive pressurized gas from the pressurized gas source **92** and may fluidly connect the pressurized gas source **92** to the spindle passage **38**. The connection conduit **102** may receive pressurized gas from the spindle passage **38** and may supply pressurized gas to the second conduit **104**. For example, the connection conduit **102** may extend through a hole in the hub cap **52** and may be connected to the second conduit **104** with a fitting **106**. The second conduit **104** may receive pressurized gas from the connection conduit **102** and may supply pressurized gas to the tire **60**. The routing of the conduits between the pressurized gas source **92** and a tire **60** that is shown in FIG. 1 is exemplary and is not meant to be limiting as other conduit routing paths may be provided. In addition, one or more valves may be associated with or provided with a conduit to enable or disable the flow of the pressurized gas from the pressurized gas source **92** to one or more tires **60**. The flow of pressurized gas is represented by the arrows located near the conduits in FIG. 1.

Referring to FIGS. 3, 5, and 7, exemplary interfaces between the wheel end assembly **24** and the gas supply subsystem **94** are shown. In each configuration, pressurized gas may be routed through the spindle passage **38** to the connection conduit **102**. In addition, the fastener **42** is omitted from FIGS. 3, 5, and 7 for clarity.

Referring to FIGS. 2 and 3, a first example of an interface is shown. In this embodiment, a fitting **110** and a fastener tube **112** are employed.

The fitting **110** may receive pressurized gas from the spindle passage **38** and may help fluidly connect the pressurized gas source **92** to the tire **60**. The fitting **110** may have a first fitting end surface **120**, a second fitting end surface **122**, a fitting hole **124**, a first outer fitting surface **126**, a second outer fitting surface **128**, and a fitting step surface **130**.

The first fitting end surface **120** may be disposed at an end of the fitting **110**. The first fitting end surface **120** may be disposed opposite the second fitting end surface **122** and may be received in the spindle passage **38** as is best shown in FIG. 3. In addition, the first fitting end surface **120** may be spaced apart from the fastener tube **112**.

The fitting hole **124** may extend from the first fitting end surface **120** to the second fitting end surface **122**. The fitting hole **124** may receive the connection conduit **102**. In addition, the fitting hole **124** may receive pressurized gas from the spindle passage **38** and may route pressurized gas to the connection conduit **102**. A seal may be disposed in the fitting hole **124** between the connection conduit **102** and the fitting **110** to help inhibit leakage of pressurized gas between the fitting **110** and the connection conduit **102**.

The first outer fitting surface **126** may extend from the first fitting end surface **120** toward the second fitting end

5

surface 122. The first outer fitting surface 126 may at least partially define an outside circumference of the fitting 110. In addition, the first outer fitting surface 126 may be disposed in the spindle passage 38 and may engage the spindle 22 to help inhibit leakage of pressurized gas between the fitting 110 and the spindle 22.

The second outer fitting surface 128 may extend from the second fitting end surface 122 toward the first fitting end surface 120 and the fitting step surface 130. The second outer fitting surface 128 may at least partially define an outside circumference of the fitting 110 and may have a larger diameter than the first outer fitting surface 126.

The fitting step surface 130 may extend from the first outer fitting surface 126 to the second outer fitting surface 128. In at least one embodiment, the fitting step surface 130 may engage the second spindle end surface 32 to help position and inhibit axial movement of the fitting 110 with respect to the spindle 22.

Referring to FIG. 3, the fastener tube 112 may receive the fastener 42 (which is not shown in FIG. 3 for clarity) and may extend through the spindle fastener hole 40 to inhibit or prevent pressurized gas from exiting the spindle 22 via the spindle fastener hole 40. The fastener tube 112 may have a tubular configuration and may have a fastener tube hole 134 through which the fastener 42 may extend. The fastener tube 112 may extend along an axis, such as the spindle fastener hole axis 46 and may be disposed substantially perpendicular to the axis 26. The fastener tube 112 may be spaced apart from the fitting 110 and may be smaller than the spindle passage 38. As such, pressurized gas may flow around the fastener tube 112 to reach the fitting 110. The fastener tube 112 may be secured to the spindle 22 in any suitable manner, such as with an interference fit and/or one or more seals that may inhibit leakage of pressurized gas between the spindle 22 and the fastener tube 112.

Referring to FIGS. 4 and 5, a second example of an interface is shown. In this embodiment, the fitting 110 and an adapter 140 are employed. The adapter 140 is best shown in FIG. 4.

The adapter 140 may receive pressurized gas from the spindle passage 38 and may route the pressurized gas to the fitting 110. The adapter 140 may have a first end surface 150, a second end surface 152, a first outer surface 154, a second outer surface 156, an outer step surface 158, an internal surface 160, a first inner surface 162, a second inner surface 164, an inner step surface 166, an adapter fastener hole 168, and at least one adapter passage 170.

The first end surface 150 may be disposed at an end of the adapter 140. The first end surface 150 may be received in the spindle passage 38 as is best shown in FIG. 5. In addition, the first end surface 150 may be spaced apart from the spindle 22.

The second end surface 152 may be disposed opposite the first end surface 150. The second end surface may be disposed proximate or may engage a surface of the fitting 110, such as the fitting step surface 130 to help inhibit leakage of pressurized gas between the fitting 110 and the adapter 140.

The first outer surface 154 may extend from the first end surface 150 toward the second end surface 152. The first outer surface 154 may at least partially define an outside circumference of the adapter 140. In addition, the first outer surface 154 may be disposed in the spindle passage 38 and may engage the spindle 22 to inhibit or prevent leakage of pressurized gas between the spindle 22 and the adapter 140.

The second outer surface 156 may extend from the second end surface 152 toward the first end surface 150 and the

6

outer step surface 158. The second outer surface 156 may at least partially define an outside circumference of the adapter 140 and may have a larger diameter than the first outer surface 154.

The outer step surface 158 may extend from the first outer surface 154 to the second outer surface 156. In at least one embodiment, the outer step surface 158 may engage the second spindle end surface 32 to help position and inhibit axial movement of the adapter 140 with respect to the spindle 22 and/or to inhibit leakage of pressurized gas between the spindle 22 and the adapter 140.

The internal surface 160 may be disposed between and may be spaced apart from the first end surface 150 and the second end surface 152. In at least one embodiment, the internal surface 160 may be axially positioned between first end surface 150 and the outer step surface 158. The internal surface 160 may be spaced apart from the fitting 110 and the connection conduit 102 such that a chamber 180 is provided between the fitting 110 and adapter 140 that may fluidly connect the adapter passage 170 to the fitting hole 124 and/or connection conduit 102.

The first inner surface 162 may extend from the second end surface 152 toward the internal surface 160. The first inner surface 162 may at least partially define an inside circumference of the adapter 140. In addition, the first inner surface 162 may receive and may engage the fitting 110 to inhibit leakage of pressurized gas between the fitting 110 and the adapter 140.

The second inner surface 164 may extend from the internal surface 160 toward the second end surface 152 and may partially define the chamber 180. The second inner surface 164 may at least partially define an inside circumference of the adapter 140 and may have a smaller diameter than the first inner surface 162.

The inner step surface 166 may extend from the first inner surface 162 to the second inner surface 164. In at least one embodiment, the inner step surface 166 may engage a surface of the fitting 110, such as the first fitting end surface 120 to help position and inhibit axial movement of the fitting 110 with respect to the adapter 140 and/or to inhibit leakage of pressurized gas between the fitting 110 and the adapter 140.

The adapter fastener hole 168 may receive the fastener 42 (which is not shown in FIG. 5 for clarity). The adapter fastener hole 168 may extend through the adapter 140 such that the adapter fastener hole 168 may have two openings in the first outer surface 154. The adapter fastener hole 168 may be located between the first end surface 150 and the internal surface 160 and may be spaced apart from the adapter passage 170 to inhibit or prevent pressurized gas from exiting the adapter 140 via the adapter fastener hole 168. As such, the adapter passage 170 may not be fluidly connected to the adapter fastener hole 168. The adapter fastener hole 168 may extend along an axis, such as the spindle fastener hole axis 46 and may be disposed substantially perpendicular to the axis 26.

At least one adapter passage 170 may be provided with the adapter 140. In the embodiment shown in FIGS. 4 and 5, two adapter passages 170 are shown. The adapter passages 170 may be spaced apart from each other and may be disposed on opposite sides of the axis 26 and the adapter fastener hole 168. In addition, the adapter passages 170 may extend substantially parallel to each other in one or more embodiments. Each adapter passage 170 may extend from the first end surface 150 to the internal surface 160 and/or the inner step surface 166. In addition, each adapter passage 170 may be disposed between and may be spaced apart from



7

the first outer surface **154** and the adapter fastener hole **168** to help inhibit leakage of pressurized gas from the adapter **140**. The adapter passage **170** may receive pressurized gas from the spindle passage **38** and may route pressurized gas to the chamber **180** and the connection conduit **102**.

Referring to FIGS. **6** and **7**, a third example of an interface is shown. In this embodiment, the fitting **110** and an adapter **140'** are employed.

The adapter **140'** may have a similar configuration as the adapter **140** shown in FIG. **4**, but may have an adapter passage **170'** with a different configuration and may include at least one flat **190'**.

In the embodiment shown in FIGS. **6** and **7**, two flats **190'** are provided. The flats **190'** may be spaced apart from each other and may be disposed on opposite sides of the axis **26** and the adapter fastener hole **168**. In addition, the flats **190'** may extend substantially parallel to each other in one or more embodiments. Each flat **190'** may extend from the first end surface **150** to a flat step surface **192'**. The flat step surface **192'** may be disposed between the first end surface **150** and the outer step surface **158** and may extend from the flat **190'** to the first outer surface **154**. The flat step surface **192'** may extend substantially perpendicular to the axis **26** in one or more embodiments.

At least one adapter passage **170'** may be provided with the adapter **140'**. In the embodiment shown in FIG. **6**, two adapter passages **170'** are shown. The adapter passages **170'** may be spaced apart from each other and may be disposed on opposite sides of the axis **26**. In addition, the adapter passages **170'** may be coaxially disposed in one or more embodiments. Each adapter passage **170'** may extend from a flat **190'** to the chamber **180**. For instance, the adapter passage **170'** may extend from a flat **190'** to the internal surface **160** and/or the second inner surface **164**. In addition, each adapter passage **170'** may be disposed between a corresponding flat **190'** and the adapter fastener hole **168** such that the adapter passage **170'** is spaced apart from the adapter fastener hole **168** to inhibit leakage of pressurized gas from the adapter **140'** through the adapter fastener hole **168**. As such, the adapter passage **170'** may not be fluidly connected to the adapter fastener hole **168**. In addition, the adapter passage **170'** may be completely disposed between the adapter fastener hole **168** and the fitting **110**. Pressurized gas in the spindle passage **38** may flow between the spindle **22** and the flat **190'** and to the adapter passage **170'**, which may route the pressurized gas to the chamber **180** and the connection conduit **102**.

While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention. Additionally, the features of various implementing embodiments may be combined to form further embodiments of the invention.

What is claimed is:

1. A tire inflation system comprising:

a spindle that rotatably supports a wheel, the spindle including:

a spindle passage through which a pressurized gas flows for inflating a tire, wherein the spindle passage is disposed along a spindle axis; and

a spindle fastener hole that extends through the spindle and that intersects the spindle passage;

8

a fitting that is disposed in the spindle passage, wherein the fitting receives the pressurized gas from the spindle passage and is fluidly connected to the tire;

a fastener tube that extends through the spindle fastener hole, wherein the fastener tube inhibits pressurized gas from flowing from the spindle passage into the spindle fastener hole; and

a fastener that extends through the fastener tube to inhibit movement of a spindle nut that is disposed on the spindle.

2. The tire inflation system of claim **1** wherein the fitting is axially spaced apart from the fastener tube.

3. The tire inflation system of claim **1** wherein the fastener tube is disposed substantially perpendicular to the spindle axis.

4. The tire inflation system of claim **1** wherein the fastener is a cotter pin.

5. The tire inflation system of claim **1** further comprising a pressurized gas source that supplies the pressurized gas and that is fluidly connected to the spindle passage with a first conduit.

6. The tire inflation system of claim **5** wherein the tire is disposed on the wheel and the fitting is fluidly connected to the tire by way of a second conduit.

7. The tire inflation system of claim **1** wherein the spindle fastener hole extends along a spindle fastener hole axis that intersects the spindle axis and is disposed substantially perpendicular to the spindle axis.

8. The tire inflation system of claim **1** wherein the fastener tube is fixedly positioned with respect to the spindle.

9. The tire inflation system of claim **1** wherein the fitting has a first fitting end surface, a second fitting end surface disposed opposite the first fitting end surface, a fitting hole that extends from the first fitting end surface to the second fitting end surface, and a first fitting outer surface that extends from the second fitting end surface toward the first fitting end surface, wherein the first fitting outer surface is received in the spindle passage.

10. The tire inflation system of claim **9** wherein the fitting hole receives a connection conduit that extends from the second fitting end surface toward the first fitting end surface such that the connection conduit does not extend to the first fitting end surface.

11. The tire inflation system of claim **9** wherein the spindle passage extends along the spindle axis from a first spindle end surface to a second spindle end surface and the fitting includes a second fitting outer surface that extends from the second fitting end surface toward the first fitting outer surface and a fitting step surface that extends from the first fitting outer surface to the second fitting outer surface, wherein the fitting step surface engages the second spindle end surface and the second fitting outer surface is not received in the spindle passage.

12. The tire inflation system of claim **11** wherein the first fitting outer surface engages the spindle in the spindle passage.

13. The tire inflation system of claim **11** wherein the fitting step surface is disposed substantially perpendicular to the spindle axis.

14. The tire inflation system of claim **9** wherein the first fitting end surface is disposed substantially perpendicular to the spindle axis.

15. The tire inflation system of claim **14** wherein the second fitting end surface is disposed substantially perpendicular to the spindle axis.

16. The tire inflation system of claim **15** wherein the spindle fastener hole extends along a spindle fastener hole

axis that intersects the spindle axis and is disposed substantially perpendicular to the spindle axis.

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